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(54) DOOR BEAM MATERIAL MADE OF ALUMINUM ALLOY

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a door beam material in which stress concentration at the time of bending deformation and fracture at an early stage based on this stress concentration are prevented, large in maximum loads and high in the amt. of energy to be absorbed.

SOLUTION: This is an extruded material of an Al-Zn-Mg series aluminum alloy contg. 0.8 to 1.5% Mg and 4 to 7% Zn or an Al-Si-Mg series aluminum alloy contg. 0.5 to 1.5% Si and 0.5 to 1.3% Mg, and the thickness of a recrystallized layer on the surface is regulated to $\leq 50 \mu\text{m}$. The part below the crystallized layer is composed of a fibrous structure. Furthermore, it is possible that there is no recrystallized layer and a fibrous structure is present on the surface.

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ABSTRACT:

PROBLEM TO BE SOLVED: To obtain a door beam material in which stress concentration at the time of bending deformation and fracture at an early stage based on this stress concentration are prevented, large in maximum loads and high in the amt. of energy to be absorbed.

SOLUTION: This is an extruded material of an Al-Zn-Mg series aluminum alloy contg. 0.8 to 1.5% Mg and 4 to 7% Zn or an Al-Si-Mg series aluminum alloy contg. 0.5 to 1.5% Si and 0.5 to 1.3% Mg, and the thickness of a recrystallized layer on the surface is regulated to $\leq 50 \mu\text{m}$. The part below the crystallized layer is composed of a fibrous structure. Furthermore, it is possible that there is no recrystallized layer and a fibrous structure is present on the surface.

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CLAIMS

[Claim(s)]

[Claim 1] Mg: Door beam material made from an aluminium alloy characterized by being the extruded material of the aluminum-Zn-Mg system aluminium alloy containing 0.8-1.5% (it is below the same% of the weight) and Zn:4-7%, and the thickness of a surface recrystallized layer being 50 micrometers or less.

[Claim 2] Door beam material made from an aluminium alloy indicated by claim 1 characterized by being the aluminium alloy with which the above-mentioned aluminum-Zn-Mg system aluminium alloy contains one sort chosen from Mg:0.8-1.5%, Zn:4-7%, Ti:0.005-0.3%, Cu:0.05-0.6%, Mn:0.2-0.7%, Cr:0.05-0.3%, and Zr:0.05-0.25%, or two sorts or more, and the remainder consists of aluminum and an unescapable impurity.

[Claim 3] Si: Door beam material made from an aluminium alloy characterized by being the extruded material of the aluminum-Si-Mg system aluminium alloy containing 0.5-1.5% and Mg:0.5-1.3%, and the thickness of a surface recrystallized layer being 50 micrometers or less.

[Claim 4] Door beam material made from an aluminium alloy indicated by claim 3 characterized by being the aluminium alloy with which the above-mentioned aluminum-Si-Mg system aluminium alloy contains one sort chosen from Si:0.5-1.5%, Mg:0.5-1.3%, Ti:0.005-0.2%, Cu:0.1-0.7%, Mn:0.05-0.6%, Cr:0.05-0.2%, and Zr:0.05-0.2%, or two sorts or more, and the remainder consists of aluminum and an unescapable impurity.

[Claim 5] Door beam material made from an aluminium alloy indicated by either of claims 1-4 characterized by fibrous structure existing under a recrystallized layer.

[Claim 6] Door beam material made from an aluminium alloy indicated by either of claims 1-4 characterized by a recrystallized layer not existing.

[Claim 7] Door beam material made from an aluminium alloy indicated by claim 6 characterized by fibrous structure existing in a front face.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the door beam material made from an aluminium alloy used as a member for door reinforcement of an automobile.

[0002]

[Description of the Prior Art] As for the door beam of a passenger car, the load absorptivity ability at the time of a collision is required as the role. For example, although the bending load value over the load and the reference value fixed in the amount of energy-absorbing expressed in a load-deformation-related area are established in FMVSS (U.S. Muraji [Kuniyasu] all specification) when a load is finally given from the side face of a real vehicle They are estimated by the bendability ability of three-point bending which supports the both ends of door beam material and presses the center section with a load fixture as generally shown in drawing 2 (a) supposing the collision concerning a car on laboratory level.

[0003] Although drawing 2 (b) is the mimetic diagram of the (Load P)-displacement (delta) curve obtained by the bending test of drawing 2 (a), and signs that reach maximum load soon, bear and carry out buckling distortion to a load on the way, and a load falls are shown if a variation rate becomes large It is supposed that the one where maximum load is large, a variation rate until it buckles and fractures is large, and the amount of energy-absorbing (area) is larger is generally desirable in a this (load P)-displacement (delta) curve.

[0004] Although the high ten steel of 150 kgf(s)/mm two classes was generally used, as for the conventional door beam, application of an aluminum extruded section came to be considered from a viewpoint of lightweight-izing. For example, the door beam which the door beam which processed the aluminum-Zn-Mg system aluminium alloy extruded section T6 is indicated [door beam], and made the recrystallized layer with a thickness of 70 micrometers or more form in JP,5-247575,A at the outside surface of an aluminum-Zn-Mg system aluminium alloy extruded material or an aluminum-Si-Mg system aluminium alloy extruded material is indicated by JP,5-311309,A.

[0005]

[Problem(s) to be Solved by the Invention] In above-mentioned JP,5-247575,A, although the recrystallized layer with a thickness of 70 micrometers or more is made to form in the outside surface of an aluminum-Zn-Mg system aluminium alloy extruded material or an aluminum-Si-Mg system aluminium alloy extruded material, if a recrystallization grain has large elongation compared with fibrous structure, therefore this recrystallized layer is given to the outside surface of the extruded material which tensile force produces according to a bending load by the thickness of 70 micrometers or more, it will be hard coming to fracture this, and it is based on the view that the amount of energy-absorbing can be raised.

[0006] On the other hand, the need of raising further maximum load and the amount of energy-absorbing came out of the demand to the engine performance of a door beam, without increasing the increase of severity, and its weight gradually. As an example, although level of the maximum load according at above-mentioned JP,5-247575,A to the bending test of an aluminum-Zn-Mg system

aluminium alloy extruded material is made into 1100kg class in a certain type of a car and some bending conditions, if it is the same bending conditions in the same cross-section configuration, current will require 1300kg class.

[0007] However, when high mho designs (a component, extrusion conditions, heat treatment, etc.) are carried out according to a demand of the maximum load of such high level, it has turned out that this recrystallized layer reduces the amount of energy-absorbing on the contrary. This is for surface deterioration's occurring in a bending deformation process, if the recrystallized layer is thickly formed in the front face, and becoming the notch in which this surface deterioration carries out stress concentration, and causing fracture of a door beam at an early stage. Recently, the door beam application vehicle especially spreads out also in the small-size car with short door die length, since the span is short, a small bending stroke (δ) also becomes large and the curvature of bending is easy to result in fracture at the part and a twist early stage. In addition, the stress concentration which considers a recrystallized layer as a cause does not become a problem by the door beam of a low mho design of level conventionally. In addition, when calling it a high mho design by this invention, by the aluminum-Zn-Mg system, two or more [32kg //mm] go [40 kgf(s)/mm² or more and an aluminum-Si-Mg system] into the category in general by proof stress.

[0008] Without increasing weight about the aluminium alloy extruded material of the presentation indicated by JP,5-247575,A, this invention persons had large maximum load, and examined many things about the gestalt of a component presentation and an outside-surface organization for the purpose of obtaining door beam material with a large energy absorbed amount. or [consequently, / making thickness of a recrystallized layer small, when the level of maximum load is raised] -- or by losing, the stress concentration at the time of bending deformation was prevented, and it found out that the amount of energy-absorbing could be raised. This invention can be made based on this knowledge.

[0009]

[Means for Solving the Problem] The door beam material concerning this invention is an extruded material of the aluminum-Si-Mg system aluminium alloy containing the aluminum-Zn-Mg system aluminium alloy containing Mg:0.8-1.5% and Zn:4-7% or Si:0.5-1.5%, and Mg:0.5-1.3%, and is characterized by the thickness of a surface recrystallized layer being 50 micrometers or less.

[0010] Although an aluminum-Zn-Mg system aluminium alloy contains Mg:0.8-1.5% and Zn:4-7% and also may contain other components suitably As a desirable presentation, Mg:0.8-1.5%, Zn:4-7%, and Ti:0.005-0.3%, Cu: 0.05-0.6%, Mn:0.2-0.7%, Cr:0.05-0.3%, Although contain one sort chosen from Zr:0.05-0.25%, or two sorts or more, and the remainder can mention aluminum and an unescapable impurity, and an aluminum-Si-Mg system aluminium alloy contains Si:0.5-1.5% and Mg:0.5-1.3% and also other components may be included suitably As a desirable presentation, Si:0.5-1.5%, Mg:0.5-1.3%, and Ti:0.005-0.2%, Cu: One sort chosen from 0.1-0.7%, Mn:0.05-0.6%, Cr:0.05-0.2%, and Zr:0.05-0.2% or two sorts or more are contained, and the remainder can mention aluminum and an unescapable impurity.

[0011] Especially in this invention, fibrous structure exists under a surface recrystallized layer. However, a surface recrystallized layer does not need to exist. In addition, it is the hot-working organization regarded as fibrous structure by the extruded material, and is the thing of the grain structure lengthened for a long time by the direction of extrusion.

[0012]

[Embodiment of the Invention] Hereafter, it divides into an aluminum-Zn-Mg system and an aluminum-Si-Mg system, and the presentation of the door beam material concerning this invention is explained to a detail.

(in the case of an aluminum-Zn-Mg system)

Mg, ZnMg, and Zn are elements required in order to maintain the reinforcement of an aluminium alloy. The reinforcement of a request [Mg] of less than 0.8% and Zn at less than 4 % of the weight is not obtained. Moreover, if Mg exceeds and Zn exceeds 7% 1.5%, while the extrusion nature of an aluminium alloy will fall, elongation also falls, and a necessary characteristic value is no longer acquired. Therefore, they may be Mg:0.8-1.5% and Zn:4-7%. In addition, this is equivalent to Mg rich

[said JP,5-247575,A] side.

[0013] Ti is an element indispensable for detailed-izing of an ingot organization. It will be saturated if [than 0.3%] more [the effectiveness of detailed-izing is not enough if there is less Ti than 0.005%, and], and a huge compound will be generated. Therefore, the content of Ti is made into 0.005 - 0.3%.

[0014] Cu, Mn, Cr, and Zr -- the element of these raises the reinforcement of an aluminium alloy. Moreover, Cu improves the stress-corrosion-cracking-proof nature of an aluminium alloy, Mn, Cr, and Zr have the operation which forms fibrous structure in an extruded material and strengthens an alloy, and one sort or two sorts or more are suitably added out of these. Suitable range is Cu:0.05-0.6%, Mn:0.2-0.7%, Cr:0.05-0.3%, and Zr:0.05-0.25%. If under the minimum of the above-mentioned operation is inadequate respectively and an upper limit is exceeded, extrusion nature will worsen and, as for the case of Cu, general corrosion resistance will worsen.

[0015] Among unescapable impurity unescapable impurities, Fe is an impurity that to aluminum ground metal contained, if it exists in an alloy exceeding 0.35%, at the time of casting, will crystallize a big and rough intermetallic compound, and will spoil the mechanical property of an alloy. [most] Therefore, the content of Fe is regulated to 0.35% or less. Moreover, in case an aluminium alloy is cast, an impurity mixes from various paths, such as a metal and an intermediate alloy of an alloying element. Although the element to mix is various, if impurities other than Fe are 0.15% or less in a total amount, they will hardly affect the property of an alloy 0.05% or less alone. Therefore, these impurities are made alone and make them 0.15% or less in a total amount 0.05% or less.

[0016] (in the case of an aluminum-Si-Mg system)

Si, MgSi, and Mg are elements required in order to maintain the reinforcement of an aluminium alloy. The reinforcement of a request [Si] of less than 0.5% and Mg at less than 0.5 % of the weight is not obtained. On the other hand, if Si exceeds and Mg exceeds 1.3% 1.5%, while the extrusion nature of an aluminium alloy will fall, elongation also falls, and a necessary characteristic value is no longer acquired. Therefore, they may be Si:0.5-1.5% and Mg:0.5-1.3%. On the other hand, about Ti, Cu, Mn, Cr, Zr, and an unescapable impurity, it is limited within the limits of the above by the same reason as an aluminum-Zn-Mg system.

[0017] Next, the organization of an extruded material is explained. If the recrystallized layer is thickly formed in the front face, surface deterioration will occur in a bending deformation process, this surface deterioration will serve as a notch of stress concentration, and fracture of a door beam will be caused at an early stage, consequently the amount of energy-absorbing will decrease. However, like this invention, when a recrystallized layer is as thin as 50 micrometers or less, or when a recrystallized layer does not exist, fibrous structure will exist in the bottom of a thin recrystallized layer, or a front face, and surface deterioration does not occur on a front face in the process in bending deformation extent planned at the door beam, therefore a surface deterioration part does not become the notch of stress concentration. In addition, what is connected with fracture of a door beam among the recrystallized layers formed on the surface of an extruded material is a recrystallized layer formed in the near front face which becomes the outside of bending. Therefore, it considers as the thickness of the recrystallized layer measured on the near front-face which serves as thickness of the recrystallized layer as used in the field of this invention on the outside of bending of a door beam.

[0018] The recrystallized layer on the front face of an extruded material is generated because the surface layer which receives large deformation especially at the time of extrusion causes recrystallization with the heat which the extruded material itself holds in an extrusion process. Therefore, generation or growth of a recrystallized layer can be prevented by taking extrusion temperature and a small extrusion rate, or adopting a multi-hole extrusion method and taking a comparatively small extrusion ratio. Also by furthermore quenching only the surface layer of an extruded material [near the dice outlet location of the downstream of an extrusion dice], it is effective in preventing generation of a recrystallized layer, or subsequent growth.

[0019] As the manufacture approach of the extruded material which has the above-mentioned organization which specifies to this invention in the aluminum-Zn-Mg system aluminium alloy of the above-mentioned component presentation For example, soaking condition;450 degree-C-500 degree C,

extrusion temperature; 400-500 degrees C, Extrusion rate; 6-10m part [for /], extrusion ratio;35-70, and aging condition;130-170-degree-Cx 6 - 12 hours are mentioned. Spraying the nitrogen gas furthermore cooled on the extruded material front face [near the extrusion dice outlet location], and preventing the rise of the product temperature immediately after disconnection from an extrusion dice is mentioned. moreover, as the manufacture approach of the extruded material which has the above-mentioned organization which specifies to this invention in the aluminum-Si-Mg system aluminium alloy of the above-mentioned component presentation For example, soaking condition;480 degree-C-550 degree C, extrusion temperature; 480-550 degrees C, Extrusion rate; 6-12m part [for /], extrusion ratio;35-70, and aging condition;150-200-degree-Cx 4 - 16 hours are mentioned. Spraying the nitrogen gas furthermore cooled on the extruded material front face [near the extrusion dice outlet location], and preventing the rise of the product temperature immediately after disconnection from an extrusion dice is mentioned.

[0020]

[Example] Hereafter, the example of this invention is explained as compared with the example of a comparison.

(Example 1) It dissolved with the conventional method and the aluminium alloy of the component of No.1 shown in Table 1 was cast to the ingot with a diameter of 200mm. 470 degree-Cx8hr soaking of this ingot was carried out, and it extruded [part / for extrusion temperature / of 470 degrees C /, and extrusion rate/of 4m] by 2 picking (extrusion ratio 42), and the nitrogen gas cooled in the immediately after [extrusion] location was sprayed on the extruded material front face, and it cooled. The cross-section configuration of an extruded material is as being shown in drawing 1 (A). Aging treatment of 130 degree-Cx12hr was performed to this extruded material, and it considered as the test specimen of an example 1. As an example 1 of a comparison, 470 degree-Cx8hr soaking was carried out, and one was taken, and, on the other hand, it came out [part / for extrusion temperature / of 500 degrees C /, and extrusion rate/of 12m], and extruded in the same cross-section configuration (extrusion ratio 83).

Cooling by the cooled nitrogen gas in an immediately after [extrusion] location was not performed.

Aging treatment of 130 degree-Cx12hr was performed to this extruded material, and it considered as the test specimen of the example 1 of a comparison.

[0021]

[Table 1]

No.	化 学 成 分 (wt%)						
	M g	Z n	T i	C u	M n	C r	Z r
1	1.3	6.7	0.03	0.2	0.2	0.06	0.14
2	0.72*	5.5	0.04	0.07	0.02	0.02	0.18

* 本発明の規定外

[0022] In the cross section perpendicular to the direction of extrusion, measurement of the surface recrystallized-layer thickness of this test specimen divided into four equally the side (bottom flange of drawing 1 A) which turns into an outside of bending at right and left, measured the recrystallized-layer thickness from a front face for the metal texture of that division location (three places an arrow head shows) for the microphotography, and calculated the average of three places. The result is shown in Table 2. In addition, surface recrystallized-layer thickness was convention within the limits of this invention, and, for the bottom of a surface recrystallized layer, the example 1 was fibrous structure. On the other hand, surface recrystallized-layer thickness crossed the convention range of this invention, and the bottom of a surface recrystallized layer of the example 1 of a comparison was fibrous structure. Moreover, the result of having performed the bending span 950mm three-point bending test is united and shown in Table 2. if surface recrystallized-layer thickness compares the example 1 of convention within the limits of this invention with the example 1 of a comparison with thick surface recrystallized-layer thickness as shown in Table 2 -- fracture -- the variation rate is long. In addition, fracture displacement is a stroke until a crack occurs on the bending outside (inner side of a door) of a test

specimen.

[0023]

[Table 2]

	成分	表面再結晶 層厚 (μm)	形状	最大曲げ 荷重 (kgf)	破断変位 (mm)	判定
比較例 1	1	250	A	1000	180	×
実施例 1	1	20	A	1020	300	○

[0024] (Example 2) It dissolved with the conventional method and the aluminium alloy of the component of No.1 shown in Table 1 was cast to the ingot with a diameter of 200mm. 470 degree-Cx8hr soaking of this ingot was carried out, and it extruded [part / for extrusion temperature / of 460 degrees C /, and extrusion rate/of 5m] by 2 picking (extrusion ratio 35), and the nitrogen gas cooled in the immediately after [extrusion] location was sprayed on the extruded material front face, and it cooled. The cross-section configuration of an extruded material is as being shown in drawing 1 (B). Aging treatment of 130 degree-Cx12hr was performed to this extruded material, and it considered as the test specimen of an example 2. On the other hand, using the aluminium alloy of the component of No.2 shown in Table 1, the extruded material of the same cross-section configuration was obtained in the same process, the same aging treatment was performed, and it considered as the test specimen of the example 2 of a comparison.

[0025] The result of having performed the surface recrystallization thickness of this extruded material and a bending span 700mm three-point bending test is shown in Table 3. The measuring method of surface recrystallization thickness is the same as an example 1. Although surface recrystallized-layer thickness had the example 2 and the example 2 of a comparison in convention within the limits of this invention and the bottom of a surface recrystallized layer was all fibrous structure as shown in Table 3, the example 2 which has a component presentation in convention within the limits of this invention has the large maximum bending load as compared with the example 2 of a comparison which runs short of principal components, and the amount of energy-absorbing to the amount of displacement of 6 inches is large.

[0026]

[Table 3]

	成分	表面再結晶 層厚 (μm)	形状	最大曲げ 荷重 (kgf)	引張-吸収量 * (kgf・mm)	判定
比較例 2	2	30	B	1310	183300	×
実施例 2	1	20	B	1900	265100	○

* 0～6インチの引張-吸収量

[0027] (Example 3) It dissolved with the conventional method and the aluminium alloy of the component shown in Table 4 was cast to the ingot with a diameter of 200mm. 530 degree-Cx12hr soaking of this ingot was carried out, and it extruded [part / for extrusion temperature / of 530 degrees C /, and extrusion rate/of 8m] by 2 picking (extrusion ratio 35), and the nitrogen gas cooled in the immediately after [extrusion] location was sprayed on the extruded material front face, and it cooled. The cross-section configuration of an extruded material is as being shown in drawing 1 (C). Aging treatment of 130 degree-Cx12hr was performed to this extruded material, and it considered as the test specimen of an example 3. On the other hand, the extrusion rate was considered as a part for 15m/using the same aluminium alloy, and the extruded material of the same configuration manufactured on the same conditions as an example 3 was made into the test specimen of the example 3 of a comparison except having not performed cooling by the cooled nitrogen gas in an immediately after [extrusion] location.

[0028]

[Table 4]

No.	化 学 成 分 (wt %)						
	Mg	Si	Ti	Cu	Mn	Cr	Zr
3	0.7	0.9	0.01	0.6	0.6	0.12	0.12

[0029] The result of having performed the surface recrystallization thickness of this extruded material and a bending span 900mm three-point bending test (operation to [Variation rate] the amount of 300mm) is shown in Table 5. The measuring method of surface recrystallization thickness is the same as an example 1.

[0030]

[Table 5]

	成分	表面再結晶 層厚 (μm)	形状	破断変位 (mm)	最大曲げ 荷重 (kgf)	エネルギー吸収量 (kgf・mm) *	判定
比較例 3	3	480	C	220	1160	2.2×10^5	×
実施例 3	3	30	C	>300	1253	3.1×10^5	○

* 0~300mmのエネルギー吸収量

[0031] if surface recrystallized-layer thickness compares the example 3 of convention within the limits of this invention with the example 3 of a comparison with thick surface recrystallized-layer thickness as shown in Table 5 although the example 3 and the example 3 of a comparison were all fibrous structure for the bottom of a surface recrystallized layer -- fracture -- a variation rate -- long -- the maximum bending load -- large -- a variation rate -- the amount of energy-absorbing to the amount of 300mm is large.

[0032]

[Effect of the Invention] According to this invention, the early fracture based on the stress concentration at the time of bending deformation and it can be prevented, and maximum load can obtain large door beam material with a large energy absorbed amount.

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(54)【発明の名称】 アルミニウム合金製ドアビーム材

(57)【要約】

【課題】 曲げ変形時の応力集中及びそれに基づく早期の破断を防止し、最大荷重が大きくエネルギー吸収量の大きいドアビーム材を得る。

【解決手段】 Mg:0.8~1.5%、Zn:4~7%を含有するAl-Zn-Mg系アルミニウム合金、又はSi:0.5~1.5%、Mg:0.5~1.3%を含有するAl-Si-Mg系アルミニウム合金の押出材であって、表面の再結晶層の厚さが50μm以下であることを特徴とするアルミニウム合金製ドアビーム材。再結晶層の下は繊維状組織である。また、再結晶層がなく表面に繊維状組織が存在していてもよい。

【特許請求の範囲】

【請求項1】 Mg: 0.8~1.5% (重量%, 以下同じ)、Zn: 4~7%を含有するAl-Zn-Mg系アルミニウム合金の押出材であって、表面の再結晶層の厚さが50 μ m以下であることを特徴とするアルミニウム合金製ドアビーム材。

【請求項2】 上記Al-Zn-Mg系アルミニウム合金が、Mg: 0.8~1.5%、Zn: 4~7%、Ti: 0.005~0.3%と、Cu: 0.05~0.6%、Mn: 0.2~0.7%、Cr: 0.05~0.3%、Zr: 0.05~0.25%から選択された1種又は2種以上を含有し、残部がAl及び不可避不純物からなるアルミニウム合金であることを特徴とする請求項1に記載されたアルミニウム合金製ドアビーム材。

【請求項3】 Si: 0.5~1.5%、Mg: 0.5~1.3%を含有するAl-Si-Mg系アルミニウム合金の押出材であって、表面の再結晶層の厚さが50 μ m以下であることを特徴とするアルミニウム合金製ドアビーム材。

【請求項4】 上記Al-Si-Mg系アルミニウム合金が、Si: 0.5~1.5%、Mg: 0.5~1.3%、Ti: 0.005~0.2%と、Cu: 0.1~0.7%、Mn: 0.05~0.6%、Cr: 0.05~0.2%、Zr: 0.05~0.2%から選択された1種又は2種以上を含有し、残部がAl及び不可避不純物からなるアルミニウム合金であることを特徴とする請求項3に記載されたアルミニウム合金製ドアビーム材。

【請求項5】 再結晶層の下に繊維状組織が存在することを特徴とする請求項1~4のいずれかに記載されたアルミニウム合金製ドアビーム材。

【請求項6】 再結晶層が存在しないことを特徴とする請求項1~4のいずれかに記載されたアルミニウム合金製ドアビーム材。

【請求項7】 表面に繊維状組織が存在することを特徴とする請求項6に記載されたアルミニウム合金製ドアビーム材。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、自動車のドア補強用部材として使用されるアルミニウム合金製ドアビーム材に関する。

【0002】

【従来の技術】乗用車のドアビームはその役割として衝突時の荷重吸収性能が要求される。例えば、FMVSS (米国連邦安全規格) では最終的には実車の側面から負荷を与えたときにその負荷に対する曲げ荷重値と、荷重-変形量関係の面積で表されるエネルギー吸収量に一定の基準値を設けているが、それらは実験室レベルでは一般的に、車両にかかる衝突を想定し、図2(a)に示すようにドアビーム材の両端を支持しその中央部を負荷治

具で押圧する3点曲げの曲げ性能で評価される。

【0003】図2(b)は、図2(a)の曲げ試験によって得られる荷重(P)-変位(δ)曲線の模式図であり、変位が大きくなるとやがて最大荷重に達し、途中で荷重に耐えられず座屈変形して荷重が低下する様子を示すものだが、一般的に、この荷重(P)-変位(δ)曲線において、最大荷重が大きく、座屈、破断するまでの変位が大きくエネルギー吸収量(面積)が大きい方が望ましいとされている。

【0004】従来のドアビームは、一般的には150kgf/mm²クラスのハイテン鋼が使用されているが、軽量化の観点からアルミ押出材の適用が検討されるようになった。例えば特開平5-311309号公報には、Al-Zn-Mg系アルミニウム合金押出材をT6処理したドアビームが記載され、また、特開平5-247575号公報には、Al-Zn-Mg系アルミニウム合金押出材又はAl-Si-Mg系アルミニウム合金押出材の外表面に70 μ m以上の厚さの再結晶層を形成させたドアビームが記載されている。

【0005】

【発明が解決しようとする課題】上記特開平5-247575号公報では、Al-Zn-Mg系アルミニウム合金押出材又はAl-Si-Mg系アルミニウム合金押出材の外表面に70 μ m以上の厚さの再結晶層を形成させているが、これは再結晶粒は繊維状組織に比べ伸びが大きく、従って、曲げ荷重によって引張力が生じる押出材の外表面にこの再結晶層を70 μ m以上の厚さで付与すると破断しにくくなり、エネルギー吸収量を向上させることができるという考え方に基いている。

【0006】一方、ドアビームの性能に対する要求は次第に厳しさを増し、その重量を増すことなく最大荷重及びエネルギー吸収量をさらに向上させる必要が出てきた。一例として、上記特開平5-247575号公報では、Al-Zn-Mg系アルミニウム合金押出材の曲げ試験による最大荷重のレベルは、ある車種、ある曲げ条件において1100kg級とされているが、同じ断面形状で同じ曲げ条件であれば現在では1300kg級が要求されるようになっている。

【0007】ところが、このような高いレベルの最大荷重の要求に応じて高 σ 設計(成分、押出条件、熱処理等)した場合、この再結晶層がかえってエネルギー吸収量を低下させることが分かってきた。これは、表面に再結晶層が厚く形成されていると曲げ変形過程で肌荒れが発生し、この肌荒れが応力集中するノッチとなり、ドアビームの破断を早期に引き起こすためである。特に最近では、ドアビーム適用車がドア長さの短い小型車にも広がっており、スパンが短い小さい曲げストローク(δ)でも曲げの曲率が大きくなってしまい、その分、より早期に破断に到りやすくなっている。なお、再結晶層を原因とする応力集中は、従来レベルの低 σ 設計のド

Mg、Znはアルミニウム合金の強度を維持するために必要な元素である、Mgが0.8%未満、Znが4重量%未満では所望の強度が得られない。また、Mgが1.5%、Znが7%を超えるとアルミニウム合金の押出性が低下するとともに伸びも低下し、所要の特性値が得られなくなる。従って、Mg:0.8~1.5%、Zn:4~7%とする。なお、これは前記特開平5-247575号公報のMgリッチ側に相当する。

【0013】Ti
Tiは、鋳塊組織の微細化のために必須の元素である。
Tiが0.005%より少ないと、微細化の効果が十分でなく、0.3%より多いと飽和して巨大化合物が発生してしまう。従って、Tiの含有量は0.005~0.3%とする。

[0014] Cu, Mn, Cr, Zr

これらの元素はアルミニウム合金の強度を高める。また、Cuはアルミニウム合金の耐応力腐食割れ性を改善し、Mn、Cr、Zrは押出材に繊維状組織を形成して合金を強化する作用があり、これらの中から1種又は2種以上が適宜添加される。好適な範囲は、Cu：0.05～0.6%、Mn：0.2～0.7%、Cr：0.05～0.3%、Zr：0.05～0.25%である。それぞれ下限未満では上記の作用が不十分であり、また、上限を超えると、押出性が悪くなり、Cuの場合は一般耐食性が悪くなる。

【0015】不可避不純物

【0011】この発明では、特に表面再結晶層の下に纖維状組織が存在する。ただし、表面再結晶層は存在しなくてもよい。なお、纖維状組織とは押出材にみられる熟間加工組織で、押出方向に長く伸ばされた結晶粒組織のことである。

【0016】(Al-Si-Mg系の場合)

Si, Mg

Si、Mgはアルミニウム合金の強度を維持するために必要な元素である。Siが0.5%未満、Mgが0.5重量%未満では所望の強度が得られない。一方、Siが1.5%、Mgが1.3%を超えるとアルミニウム合金の押出性が低下するとともに伸びも低下し、所要の特性値が得られなくなる。従って、Si:0.5~1.5%、Mg:0.5~1.3%とする。一方、Ti、Cu、Mn、Cr、Zr、及び不可避不純物については、Al-Zn-Mg系と同様の理由で、前記の範囲内に限定される。

50 【0017】次に押出材の組織について説明する。表面

に再結晶層が厚く形成されていると、曲げ変形過程で肌荒れが発生し、この肌荒れが応力集中のノッチとなり、ドアビームの破断を早期に引き起こし、その結果、エネルギー吸収量が減少する。しかし、本発明のように再結晶層が $50\mu\text{m}$ 以下と薄いき又は再結晶層が存在しないときは、繊維状組織が薄い再結晶層の下又は表面に存在することになり、ドアビームに予定されている曲げ変形程度では、その過程で表面に肌荒れが発生せず、従って、肌荒れ部分が応力集中のノッチになることもない。なお、押出材の表面に形成される再結晶層のうち、ドアビームの破断に結びつくものは、曲げの外側になる側の表面に形成される再結晶層である。従って、本発明でいう再結晶層の厚さとは、ドアビームの曲げの外側になる側の表面で測定される再結晶層の厚さとする。

【0018】押出材表面の再結晶層は、押出時に特に大きい変形を受ける表面層が押出過程で押出材自体が保有する熱により再結晶を起こすことで生成される。従って、押出温度、押出速度を小さくとりあるいは多穴押出法を採用し押出比を比較的小さくすることで、再結晶層の生成又は成長を防止することができる。さらに押出ダイスの下流側のダイス出口位置近傍において押出材の表面層のみ急冷することによっても、再結晶層の生成又はその後の成長を防止する効果がある。

【0019】上記の成分組成のAl-Zn-Mg系アルミニウム合金において、本発明に規定する上記の組織をもつ押出材の製造方法としては、例えば、ソーキング条件； $450^{\circ}\text{C}\sim 500^{\circ}\text{C}$ 、押出温度； $400\sim 500^{\circ}\text{C}$ 、押出速度； $6\sim 10\text{m}/\text{分}$ 、押出比； $35\sim 70$ 、時効条件； $130\sim 170^{\circ}\text{C}\times 6\sim 12$ 時間が挙げられ、さらに押出ダイス出口位置近傍において押出材表面*30

*に冷却した窒素ガスを吹き付けて、押出ダイスから開放直後の製品温度の上昇を防止することが挙げられる。また、上記の成分組成のAl-Si-Mg系アルミニウム合金において、本発明に規定する上記の組織をもつ押出材の製造方法としては、例えば、ソーキング条件； $480^{\circ}\text{C}\sim 550^{\circ}\text{C}$ 、押出温度； $480\sim 550^{\circ}\text{C}$ 、押出速度； $6\sim 12\text{m}/\text{分}$ 、押出比； $35\sim 70$ 、時効条件； $150\sim 200^{\circ}\text{C}\times 4\sim 16$ 時間が挙げられ、さらに押出ダイス出口位置近傍において押出材表面に冷却した窒素ガスを吹き付けて、押出ダイスから開放直後の製品温度の上昇を防止することが挙げられる。

【0020】

【実施例】以下、本発明の実施例について、比較例と比較して説明する。

（実施例1）表1に示すNo. 1の成分のアルミニウム合金を、常法により溶解し、直径 200mm の鋳塊に鋳造した。この鋳塊を $470^{\circ}\text{C}\times 8\text{hr}$ ソーキングし、押出温度 470°C 、押出速度 $4\text{m}/\text{分}$ にて2本取りで押し出し（押出比42）、押出直後位置において冷却した窒素ガスを押出材表面に吹き付けて冷却した。押出材の断面形状は図1（A）に示すとおりである。この押出材に対し $130^{\circ}\text{C}\times 12\text{hr}$ の時効処理を行い、実施例1の供試材とした。一方、比較例1として、 $470^{\circ}\text{C}\times 8\text{hr}$ ソーキングし、押出温度 500°C 、押出速度 $12\text{m}/\text{分}$ にて、1本取りで同一断面形状に押し出した（押出比83）。押出直後位置における冷却した窒素ガスによる冷却は行わなかった。この押出材に対し $130^{\circ}\text{C}\times 12\text{hr}$ の時効処理を行い、比較例1の供試材とした。

【0021】

【表1】

No.	化 学 成 分 (wt%)						
	Mg	Zn	Ti	Cu	Mn	Cr	Zr
1	1.3	6.7	0.03	0.2	0.2	0.06	0.14
2	0.72*	5.5	0.04	0.07	0.02	0.02	0.18

* 本発明の規定外

【0022】この供試材の表面再結晶層厚の測定は、押出方向に垂直な断面において、曲げの外側になる側（図1Aの下側フランジ）を左右に4等分し、その分割位置（3箇所……矢印で示す）の金属組織を顕微鏡写真にとり、表面からの再結晶層厚を測定して3箇所の平均値を求めた。その結果を表2に示す。なお、実施例1は表面再結晶層厚が本発明の規定範囲内であり、表面再結晶層の下は繊維状組織であった。一方、比較例1は表面再結晶層厚が本発明の規定範囲を越え、表面再結晶層の下は※

※繊維状組織であった。また、曲げスパン 950mm の3点曲げ試験を行った結果を表2にあわせて示す。表2に示すように、表面再結晶層厚が本発明の規定範囲内の実施例1は、表面再結晶層厚が厚い比較例1と比較すると、破断変位が長くなっている。なお、破断変位は供試材の曲げ外側（ドアのインナー側）に割れが発生するまでのストロークである。

【0023】

【表2】

	成分	表面再結晶層厚 (μm)	形状	最大曲げ荷重 (kgf)	破断変位 (mm)	判定
比較例1	1	250	A	1000	180	×
実施例1	1	20	A	1020	300	○

【0024】(実施例2)表1に示すNo. 1の成分のアルミニウム合金を、常法により溶解し、直径200mmの鋳塊に鋳造した。この鋳塊を470℃×8hrソーキングし、押出温度460℃、押出速度5m/分にて2本取りで押し出し(押出比35)、押出直後位置において冷却した窒素ガスを押出材表面に吹き付けて冷却した。押出材の断面形状は図1(B)に示すとおりである。この押出材に対し130℃×12hrの時効処理を行い、実施例2の供試材とした。一方、表1に示すNo. 2の成分のアルミニウム合金を用い、同じプロセスで同じ断面形状の押出材を得、同じ時効処理を行い、比較例2の供試材とした。

10

*【0025】この押出材の表面再結晶厚及び曲げスパン700mmの3点曲げ試験を行った結果を表3に示す。表面再結晶厚の測定方法は実施例1と同じである。表3に示すように、実施例2、比較例2とも表面再結晶層厚は本発明の規定範囲内にあり、かつ表面再結晶層の下はいずれも繊維状組織であったが、成分組成が本発明の規定範囲内にある実施例2は、主成分が不足する比較例2と比較すると最大曲げ荷重が大きく、変位量6インチまでのエネルギー吸収量が大きくなっている。

【0026】

【表3】

	成分	表面再結晶層厚(μm)	形状	最大曲げ荷重(kgf)	144°-吸収量*(kgf・mm)	判定
比較例2	2	30	B	1310	18300	×
実施例2	1	20	B	1900	255100	○

* 0~6インチの144°-吸収量

【0027】(実施例3)表4に示す成分のアルミニウム合金を、常法により溶解し、直径200mmの鋳塊に鋳造した。この鋳塊を530℃×12hrソーキングし、押出温度530℃、押出速度8m/分にて2本取りで押し出し(押出比35)、押出直後位置において冷却した窒素ガスを押出材表面に吹き付けて冷却した。押出材の断面形状は図1(C)に示すとおりである。この押出材に対し130℃×12hrの時効処理を行い、実施例3の供試材とした。一方、同じアルミニウム合金を用い、押出速度を15m/分とし、押出直後位置における冷却した窒素ガスによる冷却は行わなかった以外は、実施例3と同一の条件で製造した同一形状の押出材を比較例3の供試材とした。

20

【0028】

【表4】

No.	化 学 成 分 (wt%)						
	Mg	Si	Ti	Cu	Mn	Cr	Zr
3	0.7	0.9	0.01	0.6	0.6	0.12	0.12

【0029】この押出材の表面再結晶厚及び曲げスパン900mmの3点曲げ試験(変位量300mmまで実施)を行った結果を表5に示す。表面再結晶厚の測定方法★

★法は実施例1と同じである。

【0030】

【表5】

	成分	表面再結晶層厚(μm)	形状	破断変位(mm)	最大曲げ荷重(kgf)	144°-吸収量*(kgf・mm)	判定
比較例3	3	480	C	220	1160	2.2×10 ⁶	×
実施例3	3	30	C	>300	1253	3.1×10 ⁶	○

* 0~300mmの144°-吸収量

【0031】実施例3及び比較例3はいずれも表面再結晶層の下は繊維状組織であったが、表5に示すように、表面再結晶層厚が本発明の規定範囲内の実施例3は、表面再結晶層厚が厚い比較例3と比較すると、破断変位が長く、最大曲げ荷重が大きく、変位量300mmまでのエネルギー吸収量が大きくなっている。

【0032】

【発明の効果】本発明によれば、曲げ変形時の応力集中

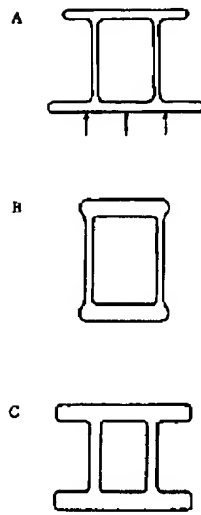
☆及びそれに基づく早期の破断を防止し、最大荷重が大きくエネルギー吸収量の大きいドアビーム材を得ることができる。

【図面の簡単な説明】

【図1】 実施例の押出材の断面形状である。

【図2】 ドアビーム材の曲げ試験方法と荷重-変位曲線を示す図である。

【図1】



【図2】

